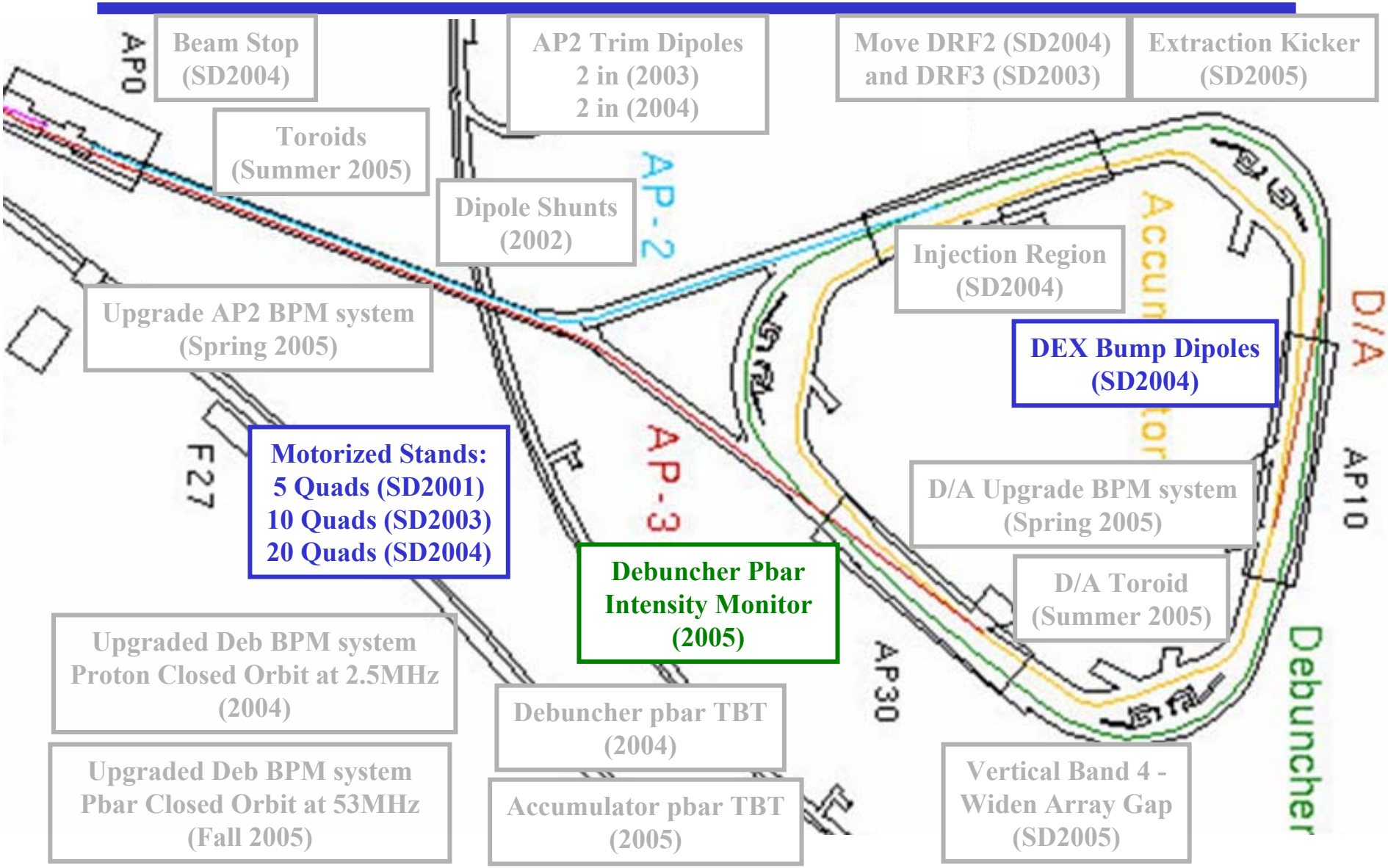
Recent Work Towards Increasing the AP2 & Debuncher Aperture

- ***Goal***
  - To increase the admittance of AP2 & Debuncher to 35 π mm-mrad for beam of initial momentum spread of ±2.25%
    - Accepting 320 π mm-mrad beam emittance
  - Transfer efficiently to Accumulator via D/A
- ***Mitigation of known limiting apertures***
- ***Orbit Control***
  - History of Debuncher orbit correction – Quad Stands
  - Debuncher Extraction Bump (D/A work & studies)
- ***Instrumentation***
  - Will be covered at a future All Experimenters' Meeting
    - Exception is Debuncher pbar Intensity monitor
- ***Lattice Modeling & Survey and Alignment***
- ***Beam Studies***
  - ***Character of studies has changed*** from predominately dedicated reverse proton studies to mostly semi-parasitic stacking studies
    - Debuncher Bumping

To Discuss today

What & Where


Beam Stop (SD2004)
AP0
AP2 Trim Dipoles 2 in (2003) 2 in (2004)
Move DRF2 (SD2004) and DRF3 (SD2003)
Extraction Kicker (SD2005)
Toroids (Summer 2005)
Dipole Shunts (2002)
AP-2
Injection Region (SD2004)
Accumulator
D/A
AP10
Upgrade AP2 BPM system (Spring 2005)
DEX Bump Dipoles (SD2004)
F27
Motorized Stands: 5 Quads (SD2001) 10 Quads (SD2003) 20 Quads (SD2004)
AP-3
D/A Upgrade BPM system (Spring 2005)
Debuncher Pbar Intensity Monitor (2005)
D/A Toroid (Summer 2005)
Upgraded Deb BPM system Proton Closed Orbit at 2.5MHz (2004)
AP30
Debuncher
Debuncher pbar TBT (2004)
Upgraded Deb BPM system Pbar Closed Orbit at 53MHz (Fall 2005)
Accumulator pbar TBT (2005)
Vertical Band 4 - Widen Array Gap (SD2005)

Limiting Apertures

Device	Horizontal		Vertical
	$\frac{\Delta p}{p}=0$	$\frac{\Delta p}{p}=2\%$ *	
Band 4 H pickup	36.8 π	36.3 π	48.7 π
Band 4 V pickup	40.5 π	39.0 π	**29.9 π**
Band 4 H kicker	36.0 π	35.5 π	48.7 π
Band 4 V kicker	41.2 π	41.1 π	**30.1 π**
Deb Extr. kicker	109.1 π	**21.9 π**	35.8 π

Not to be changed

* The numbers in this column were calculated using β-functions at $\Delta p/p = 0$

Central orbit ($\Delta p/p = 0$) limiting apertures:

Horizontal:	36.0 π mm-mrad
Vertical:	29.9 π mm-mrad

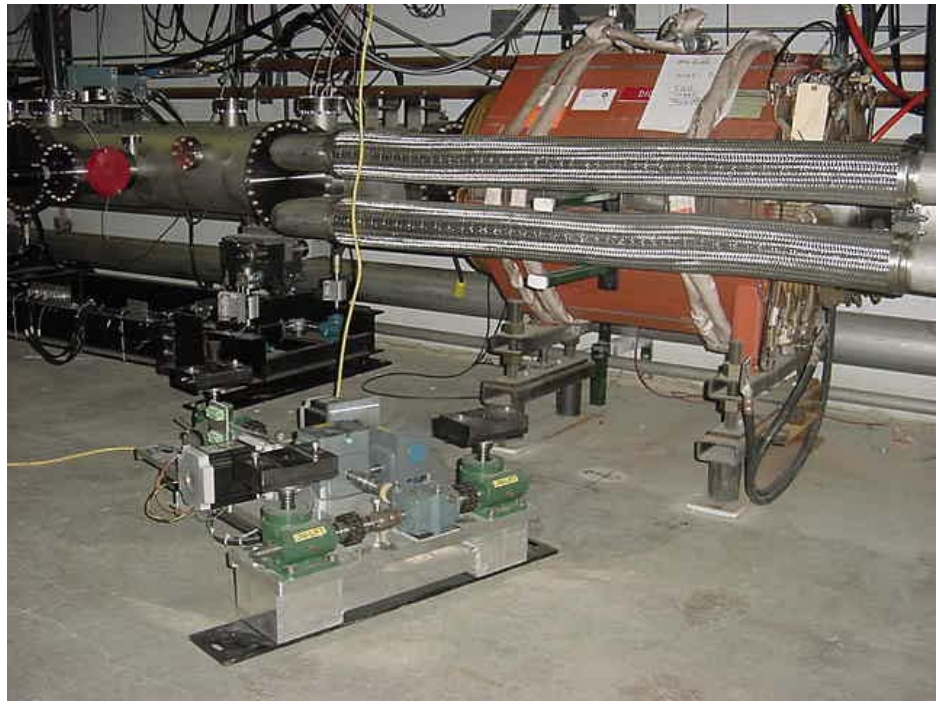
March Measurement:

29.5 π mm-mrad
24.9 π mm-mrad

Combined effect of Band 4 Vertical and Extr. Kicker upgrades is ~7.4% (from particle tracking); to be done during 2005 shutdown.

Orbit Control – Debuncher Correctors' History

Prior to Run II, there were only 12 Horizontal and 8 Vertical correctors. Many were removed for cooling upgrades. Only capable of very local bumps† for ~5% of Debuncher



In 2001 installed 5 motorized quad stands‡ for correcting ability in both planes: ~10%

Shutdown 2003 added 10 more motorized quad stands: ~25%

Shutdown 2004 added 20 more motorized quad stands: ~90%

† *Very local bumps means that bump is local to 10% of ring.*

‡ *Beam off center in quad induces a dipole kick; can correct in both planes.*

Orbit Control – Debuncher EXtraction Bump

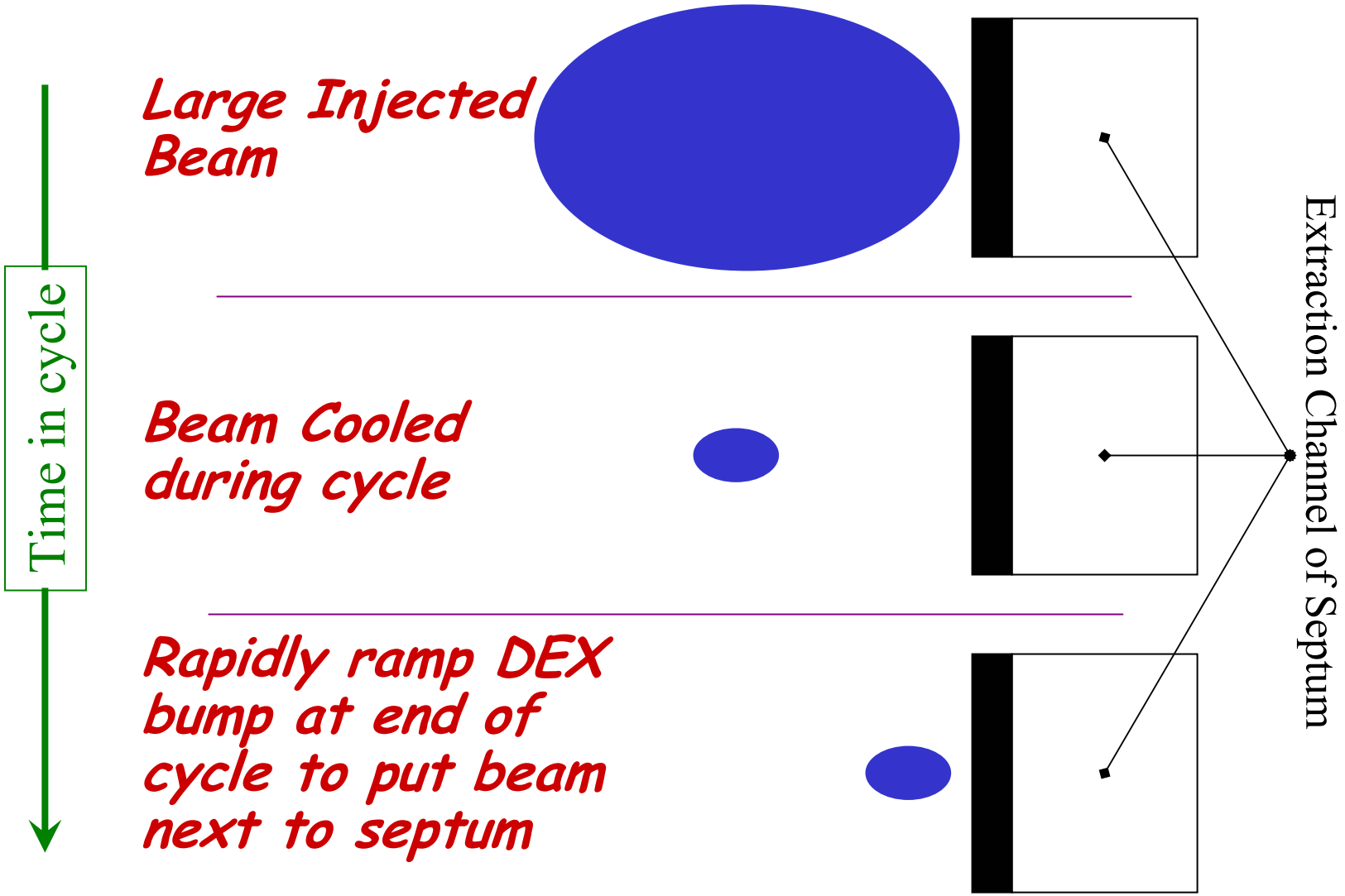
During reverse proton studies during 2004, we achieved an admittance of 33 π mm-mrad horizontally!

This was achieved with a closed orbit bump through the extraction region: horizontal position bump at the Debuncher extraction septum.

However, not able to transfer efficiently to the Accumulator via D/A beam line: bumped to far away from septum for extraction kicker.

This has led to adding a ramped Debuncher EXtraction (DEX) bump.

Orbit Control – Debuncher EXtraction Bump



Operational but not optimized; D/A studies

Component Centering & Debuncher Bumping

Requirements:

- Working intensity monitors in AP2 & Debuncher
- Store colliding & no impending transfers (RunCo)
- Stable beam to be available for 4+hr
  - No Booster or MI tuning
  - No Switchyard or NUMI tuning; permit system connected
  - Timeline stable since beam line orbits different on different events changes the injection efficiency
    - Offline analysis to disentangle effects

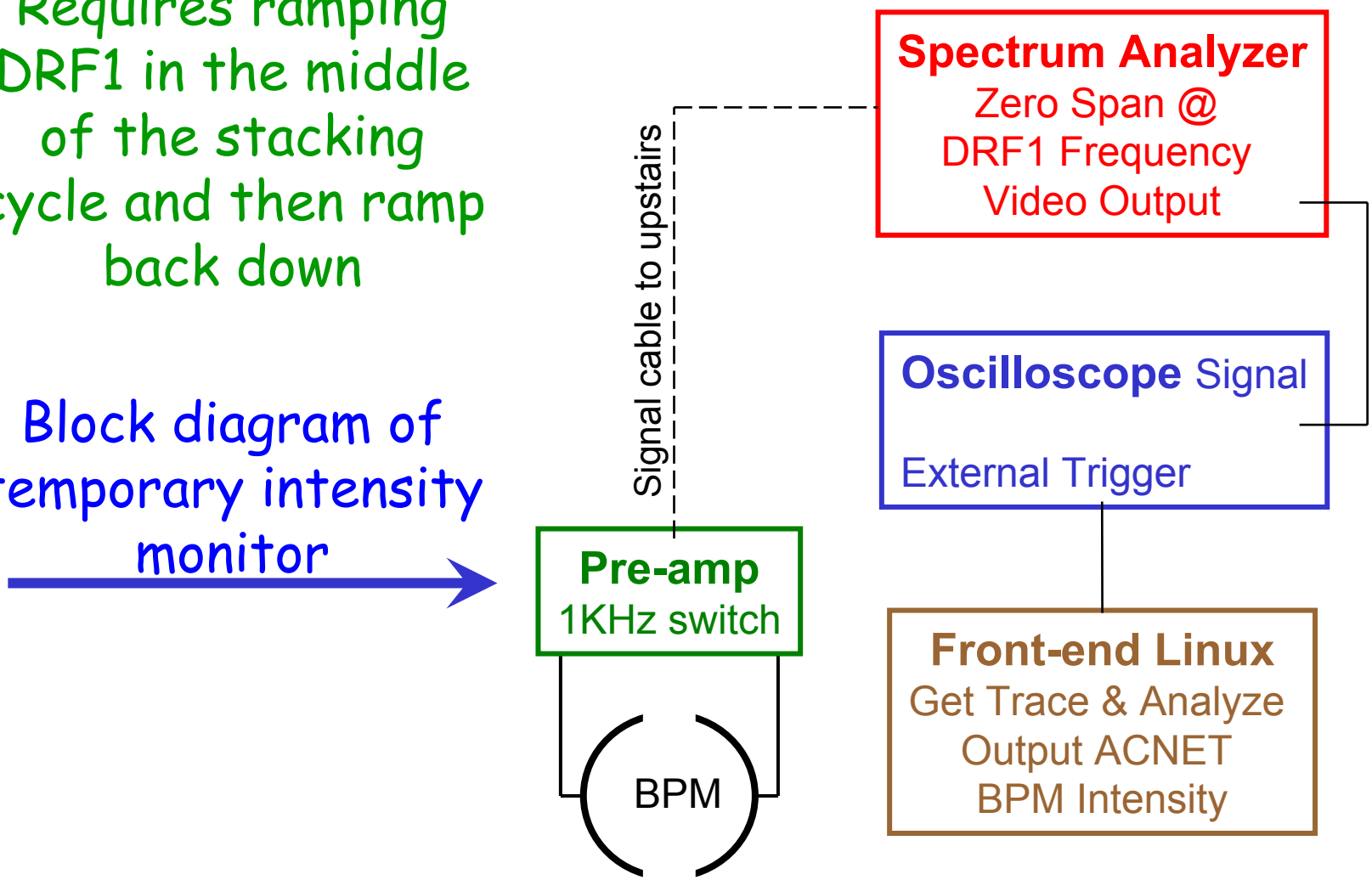
Measurement

- Move component or bump and watch Debuncher pbar intensity normalized by beam line intensity
  - Bumps are slow due to motorized quad stands (movement speed as well as only capable to move stands serially)

Debuncher Pbar Intensity Monitor

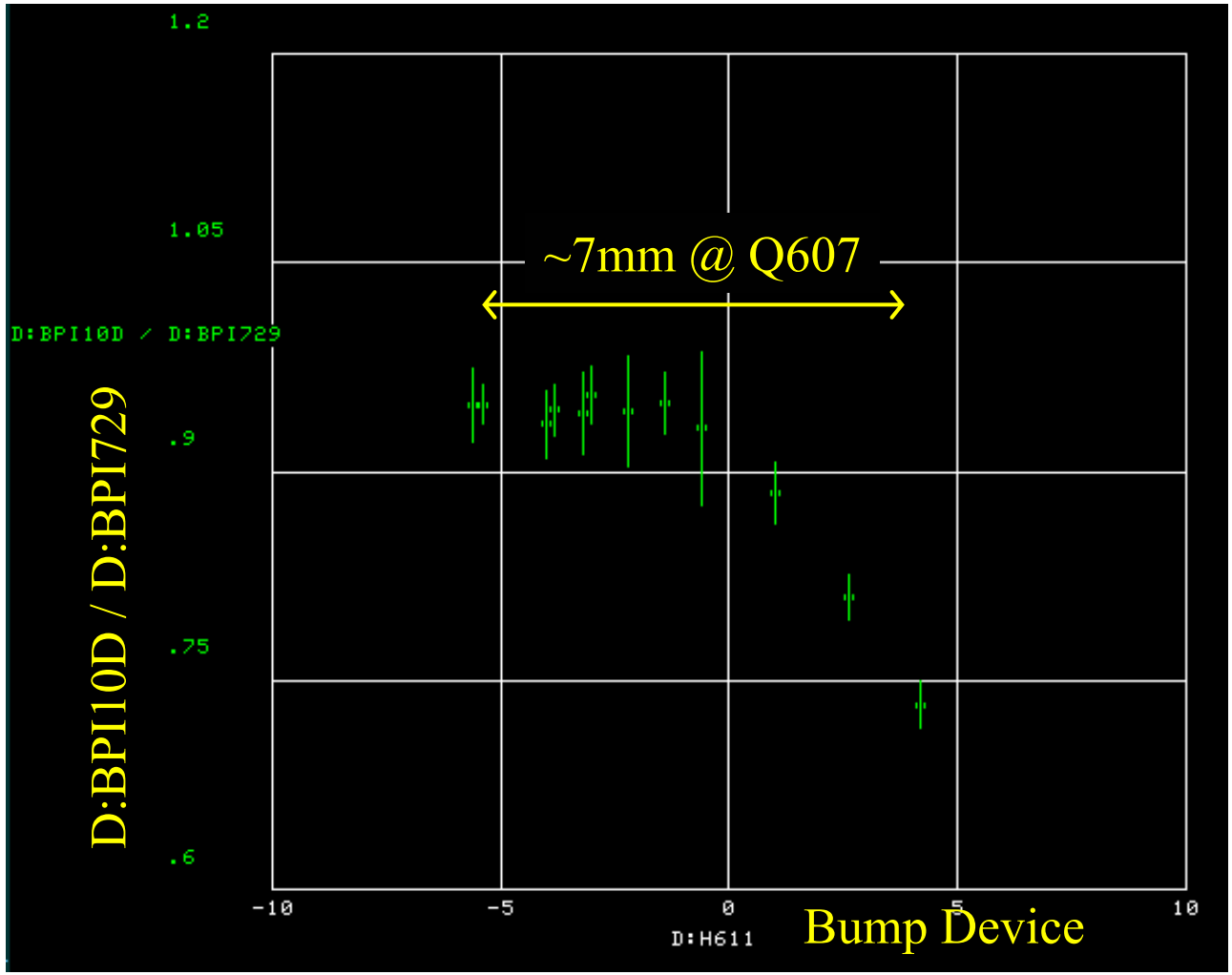
Requires ramping DRF1 in the middle of the stacking cycle and then ramp back down

Block diagram of temporary intensity monitor



Debuncher Bumping – Stacking

- Same measurement method used to center moveable devices on beam
- Constructed and verified 3-bumps that cover the Debuncher (43 horiz. + 42 vert. bumps)
- Scanning a single bump can take 10-30 minutes
- Transmission efficiency can decrease while bump device moving
- Feb-Mar ~75% of vert. bumps completed for 1st pass about Deb.
- Debuncher η change affected closed orbit; corrected late Apr



Summary

- ***Much work has been done in making tools and procedures for Beam Based Alignment***
- ***Will continue-***
  - Rounds of local bumping in Debuncher
  - Component centering about orbit after each round of bumping
  - Completing DEX bump commissioning
  - Commissioning AP2 and D2A BPM system (not discussed today)
    - Maximize/center in Debuncher injection aperture via reverse proton studies
    - Measure AP2 lattice using reverse protons
    - Center orbit in AP2 using both reverse protons and stacking secondaries